DNA on Your Plate

Suggested Grade Level: 9-12

Time: Preparation: 15-30 minutes. Soak beef jerky for 8-12 hours before use.
Length of time for classroom teaching: 2 sessions of 45-60 minutes.

Subject: science, agriculture, food science, writing.

Overview: This lab will help students better understand DNA's structure, function, and importance within all living organisms and will help them develop laboratory design skills. Students will explore the importance of DNA and beef products in their everyday lives by extracting DNA from beef jerky. The DNA extraction will help them visualize the DNA in beef and other products they find in the grocery store. Students will walk away with a better understanding of where DNA can be found, not only in the nucleus and the cell but in all living organisms and their food. Helping students visualize DNA in food allows them to understand the science behind genetic modification and demystify the process behind altering the genes of the plants that grow our food. Students will develop an understanding of DNA, traditional cross-breeding practices, and genetic modification. By using a beef product as the context for the lab, students will explore the impact of beef on the Kansas economy and careers associated with biotechnology.

Learning Objectives:

- Design and conduct a laboratory investigation to determine if cells in beef jerky have DNA in them. (Pre-lab and Laboratory)
- Analyze and interpret data collected during an investigation on DNA extraction from food. (Laboratory activity)
- Construct an explanation using evidence collected during an investigation to answer the driving question, am I eating DNA? (Laboratory activity/Post Lab)
- Describe genetic modification practices and how they have influenced agriculture.
- List careers related to agriculture and biotechnology.
- Explain the impact of the Kansas beef industry on the Kansas economy.

Background Information: *Deoxyribonucleic Acid (DNA)* is the basis of all living things. It is the genetic material that controls everything that happens in a cell. The *cell membrane* consists of a phospholipid bilayer with proteins embedded in and on the surface of the membrane. *Eukaryotic cells* also have a nuclear membrane. The nuclear membrane has the same basic structure as the cell membrane; however, it regulates what enters and leaves the nucleus providing an extra layer of protection for the eukaryotic cell's genetic material.

DNA is made of two strands that wind around each other like a twisted ladder. The rungs of the ladder are made of the four *nucleotides* adenine (A), thymine (T), guanine (G), and cytosine (C). These nucleotides pair together, A-T and C-G. Different organisms have different sequences of these four nucleotides, but the pairings are consistent across all living things. The nucleotides “spell” out different genes, which are instructions to make particular proteins. Genes are organized on chromosomes; all chromosomes in a cell make up the organism’s genome. *DNA* determines which proteins are made and directs all activities in the cell. Therefore, it also directs the entire multicellular organism. Because *DNA* is essential in cells, it is not surprising that cells evolved ways to protect the genetic material.

Extracting and isolating *DNA* requires it to be released from the cell. All cells have a cell membrane. Plant cells have an extra protective layer surrounding them called the cell wall composed of cellulose. Mechanical destruction of the cell wall will readily remove it. Animal cells simply have a *cell membrane*. Detergents and soaps break down *cell membranes* and proteins so that the *DNA* can be released. *Proteolytic enzymes (proteases)* are enzymes that break down protein. Animals, plants, fungi, and bacteria make these enzymes. Protein enzymes of proteases can be found in household products such as powder and liquid laundry detergents and dishwashing detergents, and they can be used to degrade proteins in cells and cell membranes.

When released from a cell, *DNA* typically breaks into tiny fragments. These tiny fragments have a slightly negative electric charge. Salt ions, common in many solutions, are attracted to the negative charges of the *DNA* fragments and prevent them from adhering to one another. Adding soap will break down the proteins so the *DNA* can be released. *Meat tenderizer* will further break down the protein and dissolve the *DNA*. Meat tenderizer contains enzymes that break down the proteins in tight muscle fibers, which is why it is often used to tenderize cuts of meat. At this point, the *DNA* will be fragmented or become very “sticky” and form large globs of molecular material. The *DNA* can be spooled together by using ice-cold alcohol when a small layer of alcohol is added to the top of the solution containing cellular fragments. The *DNA* will collect at the interface between the alcohol and the cell solution. The *DNA* can then be captured or spooled onto a wooden stick or glass rod. The alcohol allows the *DNA* fragments to stick together again, and you have a blob of *DNA* to examine. Although this method effectively isolates *DNA*, the *DNA* is not pure. Other materials like protein and cell fragments are carried along. Additional steps can be completed to remove proteins and cellular debris, thereby purifying the isolated *DNA*. *DNA* purification steps are not a part of this lab.

Humans have been manipulating *DNA* or the genetic material of their food for more than 10,000 years using genetic modification practices. Early practices included *cross-breeding and selective breeding* of our favorite plant and animal food sources to produce more desirable products. As science and technology advanced, we learned how genetic material is passed on from parent to offspring, and the scientific field of *biotechnology* was developed. Now *biotechnology*, the use of living organisms or biological processes to make a product, is used for many applications, from cleaning up oil slicks and finding cures for human diseases to improving crop yields and food.

Kansas Industry Information: (What should kids know about the connection of this topic to the Kansas Agriculture Industry?)
DNA research and biotechnology have been significant to agriculture. Kansas farmers and ranchers use their knowledge of DNA, genetics, and inheritance to make production decisions in crops and livestock. Kansas farmers and ranchers are constantly looking for ways to improve their management practices to increase production and improve product quality with the limited natural resources from selectively breeding cattle for carcass traits that improve meat quality or selecting a new variety of corn that was *genetically engineered* for drought resistance to produce better in a dry part of the state.

In agriculture, *biotechnology* increases crop yields, produces insect- and weed-resistant plants, and enhances vitamin and mineral content in food. Many of these advancements have been achieved by directly manipulating the *DNA* of plants and microorganisms, a process known as *genetic engineering.*

Another benefit of *genetic engineering* has been creating diversity in crops and livestock. Living Magazine explains, "Increasing genetic diversity is one of the most vital goals of GMO work. Introducing traits from dissimilar sources allows farmers to grow food that can withstand shifting climates, address varying nutritional needs of different populations, or overcome threats of pests or disease. *Genetic diversity* is essentially insurance against adverse events that would otherwise threaten our food supply." For example, if all cattle were the same, a foreign disease could devastate the entire cattle population. Diversity in breeds and other genetic components significantly decreases the possibility of one event being catastrophic to the entire population.

As of 2023, there are no *Genetically Modified Organism (GMO)* beef products on grocery store shelves; however, beef animals do consume GMO crops such as corn. "More than 95% of animals used for meat and dairy in the United States eat GMO crops. Independent studies show that there is no difference in how GMO and non-GMO foods affect the health and safety of animals (U.S. Food and Drug). Current research is being conducted on GMOs and animals. An AquAdvantage Salmon has been genetically modified to reach an important growth point faster. The GalSafe pig was developed to be free of detectable alpha-gal sugar on its cell surfaces to reduce reactions for people with Alpha-gal syndrome (AGS) (U.S. Food and Drug "GMO"). A modification in Angus cattle will change their haircoats to perform better in tropical and subtropical environments (AVM News).

"The beef cattle sector has been and continues to be the single largest sector in the Kansas agriculture industry, with cattle and calves generating $8.93 billion in cash receipts in 2019, which accounted for 55 percent of Kansas agricultural cash receipts that year. Not only does Kansas have the third largest [in the United States] number of cattle on ranches and feed yards at 6.5 million head on January 1, 2021 [more than twice the state's human population of 2.9+ million], but the state also has a significant footprint in the cattle processing sector. In 2019, Kansas produced nearly 6.03 billion pounds of red meat, or nearly 11 percent of the nation's total. According to a Kansas Department of Agriculture IMPLAN economic model, the estimated direct impact of the beef cattle ranching and farming sector, including feedlots and dual-purpose ranching and farming, is $8.8 billion in output and 37,382 jobs. Including indirect and induced effects, the total impact of the sector on the Kansas economy reaches $14.8 billion in output and 66,789 jobs…The beef industry is also recognized nationally and globally for raising healthy cattle and producing the beef consumers demand. In 2020, exports of beef and beef products from Kansas totaled over $1.4 billion and ranked first among states (GATS, 2021). Beef and beef product exports from Kansas have accounted for between 17 and 19 percent of total U.S. beef exports for each of the last five years. As the global middle class continues to grow, it is expected that global demand for protein will also increase…"(2021 Beef)

- Meatpacking and prepared meat products manufacturing make up the largest share of the food processing industry in the state. This industry employs over 31,440 people in Kansas. (Kansas Department of Labor)

- Kansas ranks third in hides and skins exported from the U.S., totaling $123.5 million in 2021. (Kansas Ag Statistics)
- In 2017, Kansas had 26,740 farms with cattle and calves. (Kansas Ag Statistics)
- Kansas ranked third in total red meat production in 2021. Beef represented nearly 5.6 billion pounds of the total. (Kansas Ag Statistics) (Kansas Livestock Association)

Materials in the kit:
- Beef jerky
- Paper filters
- Pipettes
- Centrifuge tubes
- Containers with lids
- Meat tenderizer
- Salt

Materials provided by the teacher:
- Blender or food processor
- Isopropyl alcohol (<80%)
- Water
- Soap (clear degreaser dish soap only)
- Markers (one for each group)
- Toothpicks (optional)

Tips:
Chill the isopropyl alcohol in the freezer prior to the experiment.
Only use clear dish soap in order to see the DNA.

Instructional Format:

Day 1

1. Conduct Preparatory Activities on Food Science and Careers
2. Place the beef jerky, water, and salt in a container to soak.
3. Share or review background information as time allows.

Day 2

1. Share or review background information.
2. Conduct engagement exercises.
3. Follow the procedures to conduct the lab exercise.
4. Complete the lab journal entry.

Preparation Activities on Food Science and Careers:

1. Discussion Questions: How do we know if our food is safe? Who develops new products? How is science connected to the food in the grocery store?
2. Watch this video about careers in agriculture production and processing. Ag Explorer "The Science Behind your Food Full Virtual Field Trip." 39:46 https://agexplorer.ffa.org/virtual-field-trip/archive/2017-cargill. For the sake of time, you may focus on Chapter 3: Food Scientist: The Science of Food. 5:42

Career Information to Review with Students

We use science to control the quality and safety of our food. But we also use science to advance production and create new products. Understanding the *heritability* of genetic properties has provided the historical foundation for biotechnology and the advancements we see today.

Gregor Mendel was the first person to trace the characteristics of successive generations of a living thing (peas), and his discoveries laid the foundation for biotechnology as it is practiced today. Mendel's paper about peas was first published in 1866, but the scientific community largely ignored it. Mendel was not a world-renowned scientist in his day. Rather, he was an Augustinian monk who taught natural science to high school students. His discovery of trait transfer was, at first, a theory. Genetic theory is no longer questioned in anyone's mind. Many diseases are known to be inherited, and pedigrees are commonly traced to determine disease inheritance patterns. Plants are now designed in laboratories to exhibit desired characteristics. The practical results of Mendel's research changed not only the way we perceive the world but also the way we live.

The process of transferring genetic information between plants was developed in 1973 by biochemists Herbert Boyer and Stanley Cohen when they inserted *DNA* from one bacteria into another. In 1982 the FDA approved the first consumer *GMO* product developed through genetic engineering, insulin, to treat diabetes.

The modern biotechnology processes allow scientists to select what traits an organism will have and create changes that would otherwise happen slowly over many seasons.

Many careers rely on understanding the properties of *DNA* and extracting it from cells. Whether investigating the ancestors of modern-day crops or genetically engineering a new variety of corn, DNA plays an important role in both agricultural and nonagricultural careers.

A plant scientist or genetic engineer may use *biotechnology* as a tool; these scientists may also employ biotechnologists. *Biotechnologists* work with living organisms in manufacturing and industrial settings. Biotechnologists typically do not work with the complete plant or animal but focus on cells, tissues, and even microorganisms within the larger plant or animal structure. Often, a biotechnologist works in a laboratory setting under carefully controlled conditions to change the minute systems within a single cell.

Biotechnologists can be hired to help develop new medicines and medical treatment options, assist in waste treatment or environmental remediation, or develop new characteristics in livestock and plants for agricultural use. Biotechnologists work in many sectors, including hospitals and research facilities, private food or animal production companies, pharmaceutical companies, government agencies, and food processing plants. They come from backgrounds in science and engineering or a combination of several educational groups, including chemistry, biochemistry, microbiology, life sciences, and pharmacy sciences.

Have students research careers in *biotechnology*:
Agriculture and food science technician,
Animal technician
Cell Culture Technician
Compliance Specialist
Clinical Research Associate
Glass Washer
Greenhouse or Field Technician
Laboratory Assistant
Molecular Biology Technician

Engagement:

- Discussion questions**:** Do you eat DNA? Have you eaten genetically modified organisms or GMOs? How do you know if you have or not?
- Watch the video: YouTube: What is DNA and How Does it Work? 5:23 minutes https://www.youtube.com/watch?v=zwibgNGe4aY
- Share Introductory Information: As consumers, we must understand the basics of DNA and what foods contain DNA to understand marketing promises made on food labels. Consumers worldwide are constantly inundated with marketing such as “GMO-free” or GE produce.” “In the last decade alone, the number of

shoppers avoiding genetically modified foods has tripled (from 15% to 46%) according to research by The Hartman Group based in Bellevue, WA."

- Follow-up Question: What are GMOs? Why are people afraid of eating GMOs?
- Have students research types of genetic modification and provide an example. Have students report their findings to the class. Ask students to name some GMO food available in the grocery store. (soybean oil, zucchini, papaya, canola oil, sugar made from sugar beets.)

As science advanced our understanding of DNA and how genes are passed from parent to offspring, we have learned to modify the genes being inherited in several different ways, including *selective breeding and cross-breeding* in animals, *plant cloning* (bananas), *genome duplication* (watermelon), and *induced mutation* (grapefruit) in plants.

Banana fruits are parthenocarpic, which means that they don't need to be pollinated to produce fruits. To allow for consistently high yields, with or without pollination and seed formation, bananas are propagated through cuttings which means all bananas are actually clones of each other.

Seedless watermelons were invented over 50 years ago, and they have few or no seeds. A seedless watermelon is a sterile hybrid that is created by crossing male watermelon pollen containing 22 chromosomes per cell with a female watermelon flower containing 44 chromosomes per cell. When the seeded fruit matures, the small white seeds contain 33 *chromosomes* rendering it sterile and incapable of producing seeds. This *genome duplication* is similar to *cross-breeding* a horse with a donkey and producing a sterile mule.

Ruby Red grapefruits, along with 3,000 other crop varieties consumed by millions every day, were actually created through *mutation breeding*, also known as mutagenesis. (Kastrinos, 2016)
Mutation breeding uses artificial (chemical or radiation) mutagenesis (the process of changing an organism's DNA) to obtain new cultivars or mutations that have positive attributes.

It was not until the early 1980s to mid-1990s that we began to "*genetically engineer*" our food in a way in which we created "new organisms," now coined *Genetically Modified Organisms (GMO).* The first *GMO* consumer product was a bacterial-derived form of human insulin for the treatment of diabetes in 1982, and *GMOs* did not reach grocery stores until 1994 with the arrival of the "Flavr Savr Tomato" after the Food and Drug Administration (FDA) approved it to be "as safe as traditionally bred tomatoes" (U.S. Food & Drug "Science")

According to the Kansas Farm Food Connection, the top 10 most popular *genetically modified* crops approved by the USDA are alfalfa, apple, canola, corn (field and sweet), cotton, papaya, soybeans, and squash.

Teacher Tips for the Lab Exercise: ***Caution may be needed to ensure students do not consume food products in the lab.***

1. **Use 80% alcohol and store it in the freezer before use.** Room-temperature isopropyl alcohol will still work, but students will see better results with a higher % and cold isopropyl alcohol.
2. Prepare the jerky by starting the soak the day before you do the lab exercise.

Procedures for Lab Exercise: (The teacher will perform step 3 unless a blender can be provided for each group of students).

Lab Preparation: Place the 2-3 large pieces of beef jerky, a cup of water with ¼ teaspoon of salt in a container. Stir until the salt is dissolved and let the jerky soak (the jerky should be completely covered.) Leave this soak until the jerky is soft (at least 8-12 hours is recommended)

1. Arrange the class into four tables or stations. Have them create a short group name.
2. Explain the items in the lab and pass out the items each group will need.
   a. two containers with lids
   b. two pipettes - have students use the marker to label the pipettes
      i. A for the pipette that will be used for alcohol
      ii. B for the pipette that will be used to transfer the beef slurry
   c. two paper filters
   d. dash of meat tenderizer - enough that each student can put a pinch in a centrifuge tube
3. Describe the procedures to students.
4. Pour approximately half the water from the container and pour the remaining contents into a blender. Cover and pulse the blender for a few seconds and create a jerky slurry. The mixture will be lumpy, containing small pieces of jerky (too much blending may break up the DNA and make it hard to see).
5. Pour the jerky slurry into a container. Add 2 Tablespoons (30ml) of soap and gently mix the slurry. Swirl this mixture and let it set for 10 minutes.
6. Students can use this time to answer the following questions verbally or by writing in their lab journals.
   a. Why did we soak the beef jerky? (The jerky is hard and dry, which makes it difficult to break down mechanically.)
   b. Why did we add salt to the beef jerky and water? (Salt ions are attracted to the negative charges of the DNA fragments and prevent them from adhering to one another.)
   c. What did we add soap to the jerky slurry? (The soap will break down the phospholipid bilayer of the cell and nuclear membranes.)
   d. Name one career in biotechnology, food science, or agriculture, describe what the person will do daily, and compare the work to your interests and abilities. Would you be good at this job? Why or why not?

7. Pour a small amount of beef slurry into one container for each group.
8. Each group will now strain their slurry. One student will hold the paper filter above the other container, which another student holds. A third student will pour the slurry through the filter.
9. Students will change roles and use a new filter to strain the slurry into the original container.
10. Each student, one student at a time, will use the B pipette to draw approximately .75ml slurry out of the group's container and place it in a centrifuge tube. The tube should be ⅓ full.
11. Each student will drop a small pinch of meat tenderizer into their centrifuge tube with the slurry. Then close the top and swirl to mix gently. Stirring too hard will break the DNA.
12. Each student, one student at a time, will use pipette A to draw approximately .75 ml of cold alcohol out of a container. Have students tilt the centrifuge tubes and gently drop the cold alcohol down the side to form a layer on the jerky slurry. Drop alcohol until there is about the same amount of alcohol as beef slurry. Students can then close the tubes. The alcohol will form a layer on top of the cell debris (Alcohol is less dense than water, so it floats). Let this mixture sit for 5-10 minutes. More DNA becomes visible as it sits.
13. As students wait for the DNA to become visible, they can start their lab journal entries by drawing a picture of the centrifuge tube and the layers they see. They will eventually label all of the layers in the tube.
14. Have students watch for the DNA to precipitate through the alcohol. The DNA will be clear. Small bubbles will attach to the DNA strands as they migrate up through the alcohol. Look for layers of white stringy stuff (DNA) where the layers of alcohol and beef slurry meet.
15. (optional) Students can use a toothpick to gently stir the alcohol layer and watch the strands move like a gooey substance.
16. Have students compare their results with others in their group.
17. Have groups share their results with the class so all students can compare their personal results.
18. Have students finish their lab journal entries by completing the drawing and labeling the items below.
    a. Draw the tube
    b. Label the alcohol layer
    c. Label the beef slurry layer (list the three things you added).
    d. Draw and label the DNA
    e. Record the results of each classmate in your group and make a note of the following:
        i. Who had the most visible DNA?
        ii. Why was some DNA more visible than others?
    f. Explain what GMOs are and how they are used in agriculture. Use at least five vocabulary words.

Vocabulary:

deoxyribonucleic acid (DNA): the hereditary material in humans and almost all other organisms; similar to a "blueprint" of guidelines that a living organism must follow to exist and remain functional, a self-replicating material present in nearly all living organisms as the main constituent of chromosomes; the carrier of genetic information. A chemical contained in all living organisms with the information required for growth, development, and maintenance. Microscopically, DNA resembles a ladder twisted to form a spiral (double helix). The rungs of the ladder, known as base pairs, are composed of four distinct molecules (nucleotides) identified by the letters A, T, C, and G; these four molecules are arranged in long sequences that provide the codes required for life.

cell membrane: the semipermeable membrane surrounding the cytoplasm of a cell

eukaryotic cells: cells that have a nucleus enclosed within the nuclear membrane and form large and complex organisms. Protozoa, fungi, plants, and animals all have eukaryotic cells.

nucleotides: a compound that forms the basic structural unit of nucleic acids such as DNA.

proteolytic enzymes (proteases): enzymes that break down proteins

meat tenderizer: a powder or marinade that contains enzymes that act as catalysts to speed up a chemical reaction to break down proteins

cross breeding: The act or process of producing offspring by mating purebred individuals of different breeds or varieties.

selective breeding: this practice involves choosing parents with particular characteristics to breed together and produce offspring with more desirable traits.

biotechnology: The use of living organisms or biological processes to make a product.

genetic engineering: the process of directly modifying an organism's genes using biotechnology to produce desired traits

genetic diversity: A range of different inherited traits within a species. In a species with high genetic diversity, there would be many individuals with a wide variety of different traits.

genetically modified organism (GMO): any organism whose genetic material has been altered through genetic engineering techniques.

biotechnologist: They study the physical, genetic, and chemical characteristics of cells and tissues and explore industrial applications for them and manipulate organisms or components of a biological system to create new products or processes.

plant cloning: The act of producing identical genetic plants from an original plant. Simply put, cloning is just to take the cutting/clipping of a plant and grow it elsewhere on its own.

genome duplication: The process by which additional copies of the entire genome are generated, due to nondisjunction during meiosis. The resulting cells and organisms are polyploid – they contain more than two homologous sets of chromosomes.

induced mutation: Alterations in a gene after it has come in contact with mutagens (radiation, chemical, and transposon) and environmental causes.

Gene - a DNA sequence that codes for a specific protein.

allele - one member of a pair or sequence of forms of a gene that occupies a specific site on a chromosome.
trait - a measurable or observable characteristic of an individual, i.e., coat color, birth weight, marbling, etc.
genetic markers - sequences of DNA that can be used to identify genes or individuals.
heritability - the proportion of phenotypic variation in a population that is due to genotypic variation in individuals. Measured 0 (low) to 1 (high).

Standards:
Next Generation Science
HS-LS1-1: Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins, which carry out the essential functions of life through systems of specialized cells.
HS-LS3-1: Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.
Cross-Cutting Concepts: Cause and Effect, Scale, Proportion, and Quantity, Structure and Function Scientific and Engineering Practices: Asking Questions and Defining Problems Planning and Carrying Out Investigations Constructing Explanations and Designing Solutions

Agriculture
Introduction to Agriscience - 18001
018.Agriscience in Our World
2. Connect biology, chemistry, and biochemistry to agriscience (S)
4. Identify significant historical developments in agriscience. (SS)
5. Examine important research achievements in agriscience and future research implications. (S)
020. Careers in Agriculture
2. Research a potential agriculture career based on your interests. (CD)
31. Agricultural Issues
2. Identify and describe a technological advancement that has happened in the last five years. (LA, L)
3. Research a current agriculture issue. (LA)

Workplace Skills
32. Listening Skills
1. Follows oral instructions:
a. Listen for and identify keywords.
b. Listen for words that identify a procedure.
c. Listen for steps or actions to be performed.
d. Listen for clues regarding the order or sequence in which a task is performed.

2. Distinguish fact, opinion, and inference in oral communication.
4. Analyze a speaker's point of view.
5. Draw conclusions or make generalizations from another's oral communication.

Kansas College and Career Ready Standards
W.9-10.1 Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence. a. Introduce precise claims, distinguish the claims from alternate or opposing claims, and create an organization that establishes clear relationships among claims, counterclaims, reasons, and evidence.
SL.9-10.1 Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grades 9-10 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively.
SL.9-10.2 Integrate multiple sources of information presented in diverse media or formats evaluating the credibility and accuracy of each source.
SL.9-10.3 Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric, identifying any fallacious reasoning or exaggerated or distorted evidence.
RI.9-10.11 Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on grades 9–10 reading and content, choosing flexibly from a range of strategies.
RI.9-10.11.a Use context as a clue to the meaning of a word or phrase

Grade 11-12 (Going Further Activities):
W.11-12.7 Conduct short as well as more sustained research projects to answer a question (including self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
SL.11-12.1 Initiate and participate effectively in a range of collaborative discussion (one-on-one, in groups, and teacher-led) with diverse partners on grades 11-12 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively.
RI.11-12.7 Integrate and evaluate multiple sources of information presented in media or formats as well as in words in order to address a question or solve a problem
RI.11-12.11 Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on grades 11–12 reading and content, choosing flexibly from a range of strategies.
RI.11-12.11.a Use context as a clue to the meaning of a word or phrase.

Grades 9-12:
Reason quantitatively and use units to solve problems. N.Q.1. (all) Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. ★ (N.Q.1) N.Q.2. (all) Define appropriate quantities for the

purpose of descriptive modeling. ★ (N.Q.2) N.Q.3. (all) Choose a level of accuracy **appropriate to limitations on measurement when reporting quantities. ★ (N.Q.3)**

National Agricultural Literacy Standards:
T2.9-12 c. Discuss reasons for government's involvement in agricultural production, processing, and distribution d. Evaluate evidence for differing points of view on topics related to agricultural production, processing, and marketing (e.g., grazing; genetic variation and crop
production; use of fertilizers and pesticides; open space; farmland preservation; animal welfare practices; world hunger) e. Identify inspection processes associated with food safety regulations
T3. 9-12 h. Provide examples of foodborne contaminants, points of contamination, and the
policies/agencies responsible for protecting the consumer
T4. 9-12 a. Correlate historical events, discoveries in science, and technological innovations
in agriculture with day-to-day life in various time periods d. Evaluate the benefits and concerns related to the application of technology to agricultural systems (e.g., biotechnology)
e. Identify current and emerging scientific discoveries and technologies and their possible use in agriculture (e.g., biotechnology, bio-chemical, mechanical, etc.)
f. Predict the types of careers and skills agricultural scientists will need in the future to support agricultural production and meet the needs of a growing population g. Provide examples of how processing adds value to agricultural goods and fosters economic growth both locally and globally
T5. 9-12 i. Explain the role of government in the production, distribution, and consumption of food j. Provide examples of how changes in cultural preferences influence
the production, processing, marketing, and trade of agricultural products

Supporting Resources: (supplemental teaching aids)
Naitco video: Wheat Germ DNA Extraction
https://www.youtube.com/watch?v=Mp-xZVa6iM4
Author: This lesson was adapted from a lesson authored by Anna Lukert, KFAC Curriculum Advisory Team.

References:
Barlow, Stephanie. July 18, 2017. "Where does seedless watermelon come from?" *American Farm Bureau Foundation for Agriculture*. https://www.agfoundation.org/news/where-does-seedless-watermelon-come-from.
"Berries…with a side of DNA." Towson University. https://www.towson.edu/fcsm/centers/stem/loanerlab/documents/dna-extraction-hs-manual.pdf

Bruening, G. & Lyons, J. 2000. "The case of the FLAVR SAVR tomato." California Agriculture. 54(4):6-7. https://calag.ucanr.edu/Archive/?article=ca.v054n04p6.
Cima, Greg. "Genetically modified cattle may be sold for food in the U.S." AVM News. American Veterinary Medical Association.
https://www.avma.org/news/genetically-modified-cattle-may-be-sold-food-us
"DNA: Expressions in Agriculture," *National Agriculture in the Classroom*, https://www.agclassroom.org/matrix/lesson/381/
Fuller, Hannah. October 4, 2020."Bananas: a story of clones and colonization." *Grounded Grub*.
https://groundedgrub.com/articles/bananas#:~:text=Despite%20their%20smooth%20texture%2C%20bananas,actually%20clones%20of%20each%20other.&text=This%20allows%20them%20to%20be,without%20pollination%20and%20seed%20formation."How To Extract DNA From Anything Living." *Learn. Genetics. Genetic Science Learning Center.* https://learn.genetics.utah.edu/content/labs/extraction/howto/
Kansas 2021 Ag Summit "Beef,"
https://agriculture.ks.gov/docs/default-source/ag-growth-summit/2021-growth-documents/beef.pdf?sfvrsn=15c296c1_8
Kansas Livestock Association, https://www.kla.org/resources/industry-economics
Kastrinos, Amanda. June 13, 2016. "Delicious mutant foods: Mutagenesis and the genetic modification controversy." *Genetic Literacy Project.*
https://geneticliteracyproject.org/2016/06/13/pasta-ruby-grapefruits-why-organic-devotees-love-foods-mutated-by-radiation-and-chemicals/.
Radke, Amanda. "Beef & GMOs Part 2: 5 facts about GMOs beef producers need to know." Farm Progress.
https://www.beefmagazine.com/blog/beef-gmos-part-2-5-facts-about-gmos-beef-producers-need-know
"Shunning GMOs. Consumer Worries Over GMOs Have Tripled Since 2007." July 17th, 2018.*Newsletter: The Harman Group*.
https://www.hartman-group.com/newsletters/1511163845/shunning-gmos-consumer-worries-over-gmos-have-tripled-since-2007.
U.S. Food and Drug Administration, "GMO Crops, Animal Food, and Beyond."
https://www.fda.gov/food/agricultural-biotechnology/gmo-crops-animal-food-and-beyond#:~:text=Similarly%2C%20the%20DNA%20from%20GMO,eat%20only%20non%2DGMO%20food.

U.S. Food and Drug Administration, "Science and History of GMOs and Other Food Modification Processes."
https://www.fda.gov/food/agricultural-biotechnology/science-and-history-gmos-and-other-food-modification-processes
Vogel, W. January 30, 2019. "The Science of GMOs." *Kansas Living*.
https://kansaslivingmagazine.com/articles/2018/01/30/the-science-of-gmos.
"4 Things You Need to Know about GMOs." 2022. *Kansas Farm Food Connection*.
https://kansasfarmfoodconnection.org/blog/2018/03/29/4-things-you-need-to-know-about-gmos.

DNA on Your Plate

Name:______________________________ Date:__________ Class/Hour:________________

1. Each step in the lab exercise aided in isolating the DNA from other cellular materials. Match the procedure with its function:

PROCEDURE	FUNCTION
A. Filter jerky slurry through coffee filter	___ To precipitate DNA from solution
B. Mush beef jerky with salty/soapy solution	___ Separate components of the cell
C. Initial smashing and grinding of beef jerky	___ Break open the cells
D. Addition of alcohol to filtered extract	___ Break up proteins and dissolve cell membranes

2. What did the DNA look like? Relate what you know about the chemical structure of DNA to what you observed today.

3. Explain what happened in the final step when you added alcohol to your beef jerky extract. (Hint: DNA is soluble in water but not in alcohol)

4. A person cannot see a single cotton thread 100 feet away, but if you wound thousands of threads together into a rope, it would be visible much further away. Is this statement analogous to our DNA extraction? Why or why not?

5. Why is it important for scientists to be able to remove DNA from an organism? List two reasons.